Production and characterization of slow pyrolysis biochar from lignin-rich digested stillage from 2nd generation bioethanol production.

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Lignin-rich stillage from 2nd generation bioethanol production is a unique feedstock for slow pyrolysis and biochar production, as it contains high amounts of lignin (62 wt. % d.b) and ash (9.97 wt. % d.b) next to some residual cellulose and hemicellulose. As lignin is known to result in higher char and char-C yields compared to regular lignocellulosic feedstock, the suitability of a lignin-containing residue, obtained from a 2nd generation bio-ethanol pilot run using short rotation poplar, was subjected to anaerobic digestion for biogas production followed by slow pyrolysis of the digestate for the production of biochar.

To ensure proper use of biochar as a soil amendment, guidelines put forth by both the IBI (International Biochar Initiative) as well as the EBF (European Biochar Foundation) recommend that the atomic H/C should not be higher than 0 .7 in order to guarantee its stability in soils. Unfortunately, obtaining lower H/C ratios is coincident with lower char yields. In order to find a trade-off between char yield and char H/C-ratio, the lignin-rich stillage was pyrolyzed and the effect of pyrolysis temperature (370, 410 and 450°C), heating rate (5, 20 and 50°C/min) and residence time at pyrolysis temperature (5, 15 and 45 minutes) was studied in a full factorial experimental design. Chars were produced in a gram-scale N2-gas flushed retort and were afterwards characterized using elemental and proximate analysis. To compare, straw was used as a control feedstock.

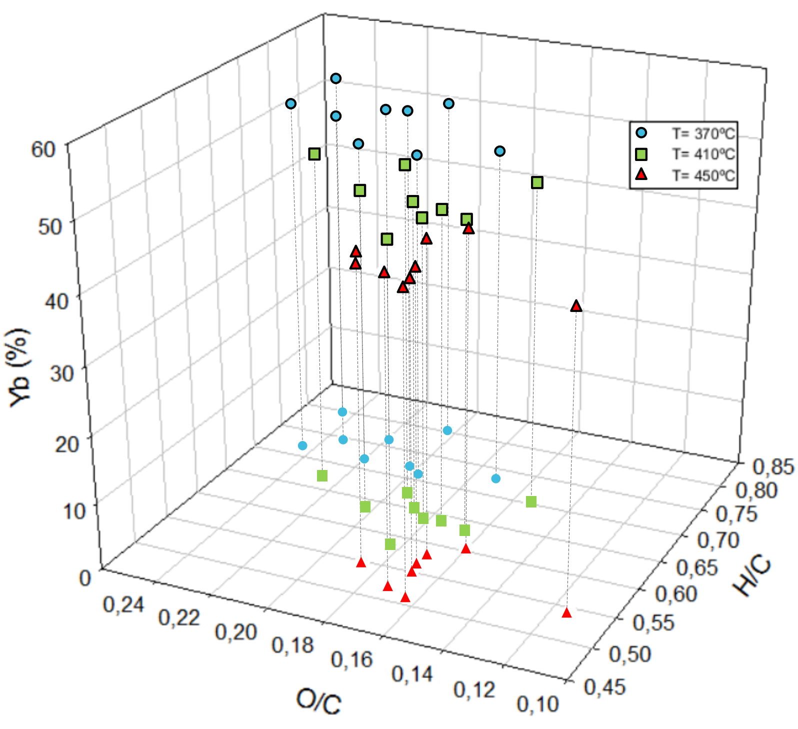

Figure 1: Biochar yield versus H/C and O/C atomic ratios produced at 3 different temperatures from digested lignin stillage.

As expected, increasing the severity of the pyrolysis conditions resulted in a consecutive decreasing biochar yield and in increasing carbon and ash contents, due to the higher release of volatile matter at these more severe pyrolysis conditions. It was concluded that biochar produced at a target temperature of 410°C would be the best in terms of stability without compromising the yield for the digested lignin residue. Finally, carbon mass and energy balances are derived for the combined anaerobic digestion (biogas) and slow pyrolysis (biochar) of the lignin rich stillage to determine the maximum value creation from the 2nd generation bio-ethanol residue.

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